time frame duration. The fourth column shows the accuracy of the switching system clock **16920** characterized by the stratum shown in the fifth column. The last four columns show the maximum time the switching system is able to operate properly (without loss due to congestion) with the LTR generated by its local clock **16920**. Notice that the clock accuracy is also the error rate of the switching system if operated responsive to an LTR generated by the local clock **16920** for a time longer than the system tolerance.

Key feature of the presented switching method: in normal operating conditions each TF is switched immediately. In particular conditions, e.g., protection, (some) TFs are delayed.

The frequency of the selected time reference is recovered and this is enough to work properly without slips. The phase can be recovered if the link length is known.

From the foregoing, it will be observed that numerous variations and modifications may be effected without departing from the spirit and scope of the invention. It is to be understood that no limitation with respect to the specific apparatus illustrated herein is intended or should be inferred. It is, of course, intended to cover by the appended claims all such modifications as fall within the scope of the claims.

<u>**WHAT IS CLAIMED IS:**</u>

1. A switching system, comprising:

a plurality of sources of Time Reference comprising at least one external source;

selection means for selecting at least one of the plurality of sources as a Local Time Reference (LTR);

a subsystem comprising a plurality of input ports and output ports, the subsystem providing for coupling of data units associated with a predefined one of a plurality of time frames, between the input ports and the output ports, responsive to the Local Time Reference (LTR);

wherein selected ones of the time frames have associated control information; and wherein the at least one source of Time Reference is encoded into the associated control information.

2. The system as in Claim 1, further comprising:

a plurality of mapping and alignment subsystems (MAS), each MAS coupled to a respective one of the input ports, and responsive to the LTR and the associated control information, for providing an aligned output that is aligned to the LTR and that contains the respective data units from the respective input port for each of the respective time frames.

3. The system as in Claim 2, wherein the associated control information is at least one of a reference ID, a time stamp, a distance in number of hops from the source selected as the LTR, a distance in time delay from the source selected as the LTR, and a time frame delimiter.

4. The system as in Claim 3, wherein the selection means selects one of the sources responsive to the associated control information.

5. The system as in Claim 4, wherein the selection means selects based upon at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

6. The system as in Claim 3, further comprising:

Synthesizing means for generating a signal output as the Local Time Reference responsive to at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

7. The system as in Claim 3, wherein the time frame delimiter has an associated Time of Arrival (ToA), the system further comprising: synthesizing means for generating a signal output as the Local Time Reference responsive to at least one of:

an averaging of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a median one of the associated Time of Arrivals for a plurality of time frames.

8. The system as in Claim 1, wherein the data units at the input ports contained within a single time frame are provided to the output ports within a single time frame.

9. The system as in Claim 1, wherein the data units at the input ports contained within a single time frame are provided to the output ports within a fraction of a time frame.

10. The system as in Claim 1, wherein the data units at the input ports contained within a single time frame are provided to the output ports within a plurality of time frames.

11. The system as in Claim 1, further comprising means for deriving the plurality of sources of time reference from the input ports, responsive to the associated control information.

12. The system as in Claim 3, wherein the time reference is derived from the time stamp and the time frame delimiter.

13. The system as in Claim 12, wherein the time stamp is representative of the Coordinated Universal Time (UTC) when the time frame delimiter was sent.

14. The system as in Claim 12, wherein the time reference is derived from the time frame delimiter by adding a defined delay to a time stamp, wherein the defined delay is the delay from a neighboring node that provides a source of the time reference.

15. The system as in Claim 1, wherein one of the sources of time reference is at least one of the following: a local source, a Coordinated Universal Time (UTC) source, and a common time source.

16. The system as in Claim 1, wherein the selection means is further comprised of configuration data defining a local source for the Local Time Reference, and is further characterized operationally in that the Local Time Reference (LTR) is selected responsive to the configuration data if the Local Time Reference is available, and if the local source for the Local Time Reference is not available, then a local source for a Common Time Reference (CTR) is selected to use as the Local Time Reference is selected if it is available, and if a local source for the Common Time Reference is not available, then at least one neighboring node is checked for the Common Time Reference to use as the Local Time Reference and if available is selected.

17. The system as in Claim 16, wherein if at least one of the neighboring nodes uses a source of CTR as its own LTR, then the selection means selects said at least one of the neighboring nodes as its Local Time Reference.

18. The system as in Claim 17, wherein each of a plurality of neighboring nodes uses a source of CTR as its respective LTR;

wherein the selection means chooses as its own LTR, the time reference of the neighboring node based upon at least one of the reference identification (ID) value, the distance in number of hops, the distance in time delay from the source, and the time frame delimiter.

19. The system as in Claim 18, wherein the selection means chooses as its own LTR the average of the time references of a plurality of the neighboring nodes.

20. The system as in Claim 19, wherein the average is calculated through a FIR filter.

21. The system as in Claim 16, wherein none of the neighboring nodes uses a source of a Common Time Reference (CTR) as its own Local Time Reference (LTR);

wherein the selection means determines a selected source for a time reference responsive to the reference ID of the control information associated with the time frame for the respective data units being coupled between the input ports and the output ports.

22. The system as in Claim 21,

wherein none of the neighboring nodes is the selected source;

wherein the selection means determines a selected source for a time reference responsive to the distance in number of hops to the selected source; and

wherein the number of hops represents the number nodes between said system and the node containing the selected source.

23. The system as in Claim 22,

wherein each of a plurality of the neighboring nodes use the selected source of time reference as its respective LTR;

wherein the selection means selects as it own LTR, the time reference of the neighboring node which is closest to the selected source; and

wherein the closest is determined from at least one of: a number of hops, a propagation delay, a propagation delay variation, a propagation delay of a selected data unit, and a propagation delay variation of at least one selected data unit.

24. The system as in Claim 16,

wherein none of the neighboring nodes uses a local source of the Common Time Reference (CTR) as its own Local Time Reference (LTR);

wherein the selection means determines a selected source for a time reference responsive to distance in number of hops to a node with a CTR source; and

wherein the number of hops represents the number nodes between said system and the node with the local CTR source.

25. The system as in Claim 24,

wherein if at least one of the neighboring nodes uses the selected source of the time reference as its own LTR, then the selection means selects and uses as its own Local Time Reference the time reference for at least one of the neighboring nodes.

26. The system as in Claim 24,

wherein each of a plurality of the neighboring nodes uses the selected source of time reference as its respective LTR;

wherein the selection means selects as it own LTR, the time reference of the neighboring node which is closest to the selected source; and

wherein closest is determined from at least one of: a number of hops, a propagation delay, a propagation delay variation, a propagation delay of a selected data unit, and a propagation delay variation of a selected data unit.

27. The system as in Claim 1, wherein the time frames are contiguous and periodic, wherein a predefined plurality of contiguous time frames define a time cycle, wherein a predefined plurality of time cycles define a super cycle;

wherein scheduling of transfer of the data units is periodic and reoccurring within at least one of the time cycles and the super cycle.

28. The system as in Claim 27,

wherein the selection means for selecting at least one of the plurality of sources as the Local Time Reference (LTR) is performed in at least every time cycle and super cycle.

29. The system as in Claim 14, wherein the time reference which is derived has a time cycle which is aligned with a time cycle of the neighboring node source of the time reference.

30. The system as in Claim 27, wherein the control information is comprised of a time stamp, wherein each of the time stamps is representative of a specific time frame number within a time cycle, and a specific time cycle number within a super cycle.

31. The system as in Claim 30, wherein the associated control information further comprises a link delay, wherein each of the time cycles or the LTR is aligned to the LTR of neighboring nodes responsive to the link delay and the time stamp.

32. A distributed switching system having an input and an output, the switching system further comprising:

a first communications switch and a second communications switch connected by at least one communications link, comprising at least one channel, for transmitting a plurality of data units from said communications link to the output of the switching system;

a plurality of sources of Time Reference comprising at least one external source;

selection means for selecting at least one of the plurality of sources as a Local Time Reference (LTR);

wherein the LTR is divided into a plurality of contiguous periodic super cycles (SCs) each comprised of at least one contiguous time cycle (TC) each comprised of at least one contiguous time frame (TF);

wherein each of the communications switches is further comprised of a plurality of input ports and a plurality of output ports, each of the input ports connected to and receiving data units from the communications link from at least one of the channels, and each of the output ports connected and transmitting data units to the communications link over at least one of the channels;

wherein each of the communications links is connected between one of the output ports on the first communications switch and one of the input ports on the second communications switch;

wherein each of the communications switches has a switch controller, coupled to the LTR, the respective input ports, and the respective output ports;

wherein each of the communications switches has a switch fabric coupled to the respective switch controller, the respective input ports, and the respective output ports;

wherein each of the switch controllers is responsive to the LTR for scheduling connection to the switch fabric from a respective one of the input ports, on a respective one of the input channels during a respective one of the time frames;

wherein each of the switch controllers defines the coupling from each one of the respective input ports for data units received during any one of the time frames, on a respective one of the channels, for output during a predefined time frame to at least one selected one of the respective output ports on at least one selected respective one of the channels; and

wherein the data units that are output during a first predefined time frame on a selected respective one of the channels from the respective output port on the first communications switch are forwarded from the respective output port of the second

communications switch during a second predefined time frame on a selected respective one of the channels responsive to the LTR.

33. The system as in Claim 32, wherein selected ones of the time frames have associated control information.

34. The system as in Claim 33, further comprising:

a plurality of mapping and alignment subsystems (MAS), each MAS coupled to a respective one of the input ports, and responsive to the LTR and the associated control information, for providing an aligned output that is aligned to the LTR and that contains the respective data unit from the respective input port for each of the respective time frames.

35. The system as in Claim 34, wherein the associated control information is at least one of a reference ID, a time stamp, a distance in number of hops from the source selected as the LTR, a distance in time delay from the source selected as the LTR, and a time frame delimiter.

36. The system as in Claim 35, wherein the selection means selects one of the sources responsive to the associated control information.

37. The system as in Claim 36, wherein the selection means selects based upon at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

38. The system as in Claim 35, further comprising:

Synthesizing means for generating a signal output as the Local Time Reference responsive to at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

39. The system as in Claim 35, wherein the time frame delimiter has an associcated Time of Arrival (ToA), the system further comprising: synthesizing means for generating a signal output as the Local Time Reference responsive to at least one of:

an averaging of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a median one of the associated Time of Arrivals for a plurality of time frames.

40. A switching method utilizing a plurality of sources of Time Reference comprising at least one external source and a subsystem comprising a plurality of input ports and output ports, the method comprising:

selection means for selecting at least one of the plurality of sources as a Local Time Reference (LTR);

dividing the LTR into a plurality of time frames;

coupling of data units associated with a predefined one of the plurality of time frames, between the input ports and the output ports, responsive to the Local Time Reference (LTR);

associating associated control information with selected ones of the time frames; and

encoding the at least one source of Time Reference into the associated control information.

41. The method as in Claim 41, further comprising:

providing an aligned output that is aligned to the LTR and that contains the respective data unit from the respective input port for each of the respective time frames responsive to the LTR and the associated control information.

42. The method as in Claim 41, wherein the associated control information is at least one of a reference ID, a time stamp, a distance in number of hops from the source selected as the LTR, a distance in time delay from the source selected as the LTR, and a time frame delimiter.

43. The method as in Claim 42, further comprising:

selecting one of the sources responsive to the associated control information.

44. The method as in Claim 43, wherein the selecting one of the sources is responsive to at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

45. The method as in Claim 42, further comprising:

generating a signal output as the Local Time Reference responsive to at least one of the reference identification (ID) value, the distance in hops, the distance in time delay from the source, and the time frame delimiter.

46. The method as in Claim 42, wherein each of the time frames has an associcated Time of Arrival (ToA), the method further comprising:

generating a signal output as the Local Time Reference responsive to at least one of:

an averaging of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a maximum one of the associated Time of Arrivals for a plurality of time frames,

a median of the associated Time of Arrivals for a plurality of time frames.

47. The method as in Claim 42, further comprising:

deriving the time reference from the time stamp and the time frame delimiter.

48. The method as in Claim 47, wherein the time stamp is representative of the Coordinated Universal Time (UTC) when the time frame delimiter was sent.

49. The method as in Claim 40, wherein one of the sources of time reference is at least one of the following: a local source, a Coordinated Universal Time (UTC) source, and a common time source.